

The Energies of All Hadrons(Including All Known Resonances) and the Energies of the Excited States of Quarks

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ABSTRACT

By means of a general classification of the different kinds of matter which were formed along the universal expansion this paper shows that the forces of nature form a chain from the world of the subatomic particles to the large bodies of the universe, the galaxies.

It is shown that matter has a generalized structured state characterized by the existence of some degree of order and by some kind of Lennard-Jones potential. The existence of such a state at the level of quarks and galaxies suggests that nature has two more fundamental forces, a superstrong interaction which acts among quarks and prequarks, and a superweak interaction which acts among galaxies.

The paper also gives a physical explanation for quark confinement. The energies of hadrons, including all known resonances, are calculated in a simple manner. One may predict the energies of all the other hadrons to be found experimentally. The excited states of quarks are also calculated. According to the work there is no need for the Higgs boson since the masses of hadrons and quarks are generated by the superstrong and strong interactions.

Key words: Cosmology - Fifth force - Particle physics - Unification of forces

I. INTRODUCTION

It has been proven beyond any doubt that the universe is expanding (1, 2, 3, 4). Recent data of several investigators show that galaxies form gigantic structures in space. De Lapparent et al.(5)(also, other papers by the same authors) have shown that they form bubbles which contain huge voids of many megaparsecs of diameter. Broadhurst et al.(6) probed deeper regions of the universe with two pencil beams and showed that there are (bubble) walls up to a distance of about 2.5 billion light-years from our galaxy. Even more disturbing is the apparent regularity of the walls with a period of about $130h^{-1}\text{Mpc}$. There is also an agglomeration of galaxies forming a thicker wall, called the great wall. It has also been reported(7, 8, 9) (also, other confirming papers) that there is a large-scale coherent flow towards a region named the Great Attractor. All this data show that galaxies form a medium in which we already observe some interactions. Kurki-Suonio et al.(10) the medium formed by them is rather a liquid than a crystalline solid. We may call this medium the ‘galactic liquid’.

The facts shown above have also been corroborated by the data of the APM survey(11) which was based on a sample of more than two million galaxies. This survey measured the galaxy correlation function $w(\theta)$. More evidence towards the same conclusion was provided by the ‘counts in cells’ of the QDOT survey(12) and more recently by the redshift(APM) survey(13) and by the power spectrum inferred from the CfA survey(14)and from that inferred from the Southern Sky Redshift Survey(15). The data from these surveys show that galaxies are not randomly distributed in space on large scales and put a shadow over the cold dark matter model(16, 17). There have been attempts to keep the cold dark matter hypothesis but only at the cost of many *ad hoc* adjustments. There are even proposals of having more than one type of dark matter(18).

Another puzzle of Nature is the existence of strange objects, such as quasars, BL Lacertae and Seyfert galaxies, and the fact of having spiral galaxies with their mysterial arms. The evolution of galaxies does not fit either in the general theoretical framework.

At the other end of the distance scale, in the fermi region, it appears now that the quark is not elementary after all. This can be implied just from their number which, now, stands at 18. Particle physics theorists have already begun making models addressing this compositeness(19).

II. GENERAL CLASSIFICATION OF MATTER

Science has utilized specific empirical classifications of matter which have revealed hidden laws and symmetries. Two of the most known classifications are the Periodic Table of the Elements and Gell-Mann’s classification of particles(which paved the way towards the quark model).

Let us go on the footsteps of Mendeleev and let us attempt to achieve a

general classification of matter, including all kinds of matter formed along the universal expansion, and by doing so we may find the links between the elementary particles and the large bodies of the universe.

It is well known that the different kinds of matter of nature appeared at different epochs of the universal expansion, and that, they are imprints of the different sizes of the universe along the expansion. Taking a closer look at the different kinds of matter we may classify them as belonging to two distinct general states. One state is characterized by a single unity with angular momentum, and we may call it, the single state. The angular momentum may either be the intrinsic angular momentum, spin, or the orbital angular momentum. The other state is characterized by some degree of correlation among the interacting particles and may be called the structured state. The angular momentum may(or may not) be present in this state. In the single states we find the fundamental unities of matter that make the structured states. The different kinds of fundamental matter are the building blocks of everything, *stepwise*. In what follows we will not talk about the weak force since it does not form any stable matter and is rather related to instability in matter. As discussed in this work it appears that along the universal expansion nature made different building blocks which filled the space. The weak force did not form any building block and is out of the initial discussion. As is well known this force is special in many other ways. For example, it violates parity in many decays and it has no “effective potential”(or static potential) as the other interactions do. Besides, the weak force is known to be left-handed, that is, particles experience this force only when their spin direction is anti-aligned with their momentum. Right-handed particles appear to experience no weak interaction, although, if they have electric charge, they may still interact electromagnetically. Later on we will include the weak force into the discussion. The single state is made by only one kind of fundamental force. In the structured state one always finds two types of fundamental forces, i.e., this state is a link between two single states. Due to the interactions among the bodies(belonging to a particular single state) one expects other kinds of forces in the structured state. In this fashion we can form a chain from the quarks to the galactic superstructures and extrapolate at the two ends towards the constituents of quarks and towards the whole universe.

The kinds of matter belonging to the single states are the nucleons, the atom, the galaxies, etc. The ‘et cetera’ will become clearer later on in this article. In the structured state one finds the quarks, the nuclei, the gasses, liquids and solids, and the galactic liquid. Let us, for example, examine the sequence nucleon-nucleus-atom. As is well known up to now nucleon is made out of quarks and held together by means of the strong force. The atom is made out of the nucleus and the electron(we will talk about the electron later), and is held together by means of the electromagnetic force. The nucleus, which is in the middle of the sequence, is held together by the strong force(attraction among nucleons) and by the electromagnetic force(repulsion among protons). In other words, we may say that the nucleus is a compromise between these two forces.

Let us, now, turn to the sequence atom-(gas,liquid,solid)-galaxy. The gasses, liquids and solids are also formed by two forces, namely, the electromagnetic and the gravitational forces. Because the gravitational force is 10^{39} weaker than the electromagnetic force the polarization in gasses, liquids and solids is achieved by the sole action of the electromagnetic force because it has two signs. But it is well known that large masses of gasses, liquids and solids are unstable configurations of matter in the absence of gravity. Therefore, they are formed by the electromagnetic and gravitational forces. The large amounts of hydrogen *gas* at some time in the history of the universe gave origin to galaxies which are the biggest individual unities of creation. We arrive again at a single fundamental force that holds a galaxy together, which is the gravitational force. There is always the same pattern: one goes from one fundamental force which exists in a single unity(nucleon, atom, galaxy) to two fundamental forces which coexist in a medium. The interactions in the medium form a new unity in which the action of another fundamental force appears. We are not talking any more about the previous unity which exists inside the new unity(such as the nucleons in the nucleus of an atom).

By placing all kinds of matter together in a table in the order of the *universal expansion* we can construct the two tables below, one for the states and another for the fundamental forces.

In order to make the atom we need the electron besides the nucleus. Therefore, just the clumping of nucleons is not enough in this case. Let us just borrow the electron for now. Therefore, it looks like that the electron belongs to a separate class and is an elementary particle. The above considerations may be summarized by the following: *the different kinds of building blocks of the Universe(at different times of the expansion) are intimately related to the idea of filling space.* That is, depending on its size, the Universe is filled with different unities.

III. THE NUMBER OF FUNDAMENTAL FORCES OF NATURE

In order to keep the same pattern, which should be related to an underlying symmetry, the tables reveal that there should be another force, other than the strong force, holding the quarks together, and that this force should hold together the prequarks. Let us name it the superstrong force. Also, for the 'galactic liquid', there must be another fundamental force at play. Because it must be much weaker than the gravitational force(otherwise, it would already have been found on Earth) we expect it to be a very weak force. Let us call it the superweak force.

Summing up all fundamental forces we arrive at *six forces for nature: the superstrong, the strong, the electromagnetic, the gravitational, the superweak and the weak forces.* We will see later on that they are interrelated. IV. THE

STRUCTURED STATE

The structured state is made by opposing forces, i.e., it represents a compromise between an attractive force and a repulsive force. Ordinary matter(gasses, liquids and solids) is formed by the polarization of the electromagnetic force. Polarization is also present in nuclear matter which may be described either in terms of the Seyler-Blanchard interaction or according to the Skirme interaction. Both give a type of Van der Waals equation of state(20, 21). It is not by chance, then, that the liquid drop model provides quite some satisfactory results in nuclear physics. In order to keep the same pattern we should expect to have a sort of compromise between the superstrong force and the strong force. This compromise forms the quark. As we will show later the superstrong interaction is mediated by three bosons. By analogy with the polarization of the electromagnetic force among molecules, we expect to have some sort of polarization among quarks also. Now, we can understand why lattice QCD yields many satisfactory results.

In order to have the ‘galactic liquid’ it is also necessary to have some sort of polarization. This means that we need dipoles and because the gravitational force is always attractive(and thus, can not be the source of such dipoles), the superweak force must be repulsive during the universal expansion. This is consistent with the idea of the expansion itself. That is, the universal expansion must be caused by this repulsive force.

The bodies which form any structured state exhibit some degree of correlation among them. This degree of correlation is shown by the correlation function which, in turn, is related to the interacting net potential energy among the particles. The potential energy has three general features: i) it has a minimum which is related to the mean equilibrium positions of the interacting particles; ii) it tends to zero as the separation among the particles tends to infinity; and iii) it becomes repulsive at close distances. A good illustration of the general features of such a potential energy is the molecular potential(Fig.1). Because of our ignorance in treating the many-body problem, it has become quite common the use of the so-called semi-empirical interatomic potential energies. Mathematically, there are a few of them. The most commonly used is the Lennard-Jones potential energy(22) which has the general form

$$V(r) = \frac{\lambda_n}{rn} - \frac{\lambda_m}{rm}. \quad (1)$$

Later on we will come back to this point. The potential energy of the ‘galactic liquid’ must also have the same general features. Therefore, it is very important to determine the mean equilibrium position of the galactic superstructures.

As is well known the general motion of the particles of a liquid is quite complex and that is exactly what we are dealing with in the case of the galactic superstructures.

The aggregation of matter into larger and larger structures is possible because of the higher orders of interaction of polarization, such as dipole-dipole, dipole-quadrupole, etc. For example, a molecule is formed by the polarization of their atoms. But there is also a polarization between two molecules. This also takes place with the constituents of the nucleus. There is a polarization between two protons and there is also a polarization between two alpha particles. As discussed above we expect to have a polarization in the formation of a quark and also in the interaction among quarks.

V. PRELIMINARY IDEAS ON PREQUARKS

The classification of matter achieved above implies that quarks are formed of prequarks. Let us develop some preliminary ideas which may help us towards the understanding of the superstrong interaction. Presumably, just as quarks do, prequarks are also supposed to be permanently confined inside baryons.

Actually, the composition of quarks is an old idea, although it has been proposed on different grounds(23). A major distinction is that in this work leptons are supposed to be elementary particles. This is actually consistent with the smallness of the electron mass which is already too small for a particle with a very small radius(24).

In order to distinguish the model proposed in this paper from other models of the literature we will name these prequarks with a different name. We may call them *primons*, a word derived from the latin word *primus* which means first.

From the above considerations quarks are composed of primons. Also, we saw above that there must be a sort of polarization in the formation of a quark. Since a baryon is composed of three quarks, it is reasonable to consider that a quark is composed of two primons which are polarized by the exchange of some kind of charge which is carried on by the corresponding boson. Let us name the exchanged particle the mixon(as we will see below the quark colors will come from the mixing of supercolors).

In order to reproduce the spectrum of 18 quarks(6 quarks in 3 color states) we need 12 primons(4 primons in 3 supercolor states). Therefore, we have 4 triplets. As to the charge, one triplet has charge $(5/6)e$ and any other triplet has charge $(-1/6)e$.

Let us assume that the exchanged particle is a boson. Since quarks have spin $1/2$, the spin of each primon has to be equal to $1/4$. In this case the boson has spin zero. At this stage we may introduce a postulate concerning the unit of quantization. As is well known the unit of quantization is \hbar . This unit of measure is arbitrary and was taken as such in order to have an agreement between experimental data and theory at the level of atomic physics. Later on this unit of measure was applied to elementary particles and up to the level of

quarks it still holds. However, at the level of the quarks constituents it may not hold anymore. We may postulate that at the level of primons the unit of quantization is $\bar{\hbar} = \hbar/2$. In this way primons are also fermions with a spin given by

$$s = \left(\frac{1}{2}\right) \bar{\hbar}. \quad (2)$$

As we will see below, this is consistent with the required properties which are needed for forming quarks out of primons.

Let us try to arrive at a possible equation for “free” primons beginning with Dirac’s equation,

$$\left(i\hbar\alpha_\mu \frac{\partial}{\partial x^\mu} - \beta mc \right) \Psi = 0 \quad (3)$$

where $\mu = 0, 1, 2, 3$. If, now, we divide this equation by 2, and make the substitutions $\hbar/2 = \bar{\hbar}$ and $\bar{\beta}/2 = \beta$, we obtain, of course, another Dirac equation. By imposing that each component Ψ_σ of Ψ must satisfy Klein-Gordon equation we obtain the following algebra, which is slightly different from Dirac’s,

$$\begin{aligned} \alpha_i \alpha_k + \alpha_k \alpha_i &= 2\delta_{ik} \\ \alpha_i \bar{\beta} + \bar{\beta} \alpha_i &= 0 \\ \alpha_i 2 &= 1 \\ \bar{\beta} 2 &= \frac{1}{4}. \end{aligned}$$

Of course, α_i are the same as in Dirac’s equation, but now $\bar{\beta} = \beta/2$.

The new Dirac equation becomes

$$\left(i\bar{\hbar}\alpha_\mu \frac{\partial}{\partial x^\mu} - \bar{\beta} mc \right) \Psi = 0 \quad (4)$$

where $\bar{\hbar}$ is a new unit of quantization and $\bar{\beta}$ is Dirac’s $\beta/2$. Of course, this equation is also Lorentz covariant.

In terms of the Hamiltonian, the new Dirac equation is

$$\left(-ic\bar{\hbar}\alpha \cdot \nabla + \bar{\beta} mc^2 + \Phi \right) \Psi = i\bar{\hbar} \frac{\partial \Psi}{\partial t} \quad (5)$$

where Φ is the field by means of which primons interact.

Since a quark has spin equal to $1/2$, only primons with parallel(or antiparallel) spins form bound states(quarks). This means that the spin wave function of a bound state(quark) is symmetrical and, because the total wave function is antisymmetrical, the rest of the wave function(which includes the superflavor, supercolor and spatial parts) has to be antisymmetrical.

The superstrong interaction should be such that only primons with different quantum numbers form bound states, that is, quarks. Taking into account the above considerations on spin and charge, we have the following table for primons(Table 3). With this table we are able to form all quarks as shown in Table 4. The colors are formed from the mixing of the supercolors as shown in Table 5.

Therefore, a prequark, p_{ij} , must transform with

- superflavor index: $i = 1, 2, 3, 4$
- supercolor index: $j = \alpha, \beta, \gamma$.

These indices must transform respectively under $SU(4)|_{superflavor}$ and $SU(3)|_{supercolor}$. Because of the selection rules the group $SU(3)|_{supercolor}$ is reduced to the subgroup $SU(2)$, and therefore the number of bosons must be 3. Because of the range these bosons must be very massive. Let us call them \aleph_1 , \aleph_2 and \aleph_3 .

We may have an estimation of the strength of the superstrong interaction in the following way. In ordinary matter(liquids, solids and gasses) which is formed by the gravitational and electromagnetic forces the energy levels are in the eV region. In nuclei which are formed by the electromagnetic and strong force the energy levels are in the MeV region, and in quarks which are formed by means of the action of the strong and superstrong forces the energy levels are in the GeV region. Therefore, *the superstrong interaction is about a thousand times stronger than the strong interaction.*

As was said at the beginning of this section the ideas on prequarks are very preliminary and a deeper understanding of the superstrong interaction, as proposed in this work, is under consideration. This understanding will begin defining the internal quantum numbers of this interaction.

VI. THE FUNDAMENTAL INTERACTIONS OF MATTER

A maximis ad minimam

It is well known that the electromagnetic interaction is mediated by a massless vector boson, the photon. The weak interaction is mediated by the three heavy vector bosons, W^+ , W^- and Z^0 . It was shown by Weinberg, Salam and Glashow that the weak and electromagnetic interactions are unified at short distances. The strong force is mediated by the pseudoscalar bosons π^+ , π^- and π^0 (also by K^0 , \bar{K}^0 and K^\pm). In a previous work(25) it was assumed that the range of the superweak interaction is infinite. This means that its mediator is a massless boson. Let us call this boson the symmetron, \mathcal{O} . As has been

shown(25) the interaction energy of the superweak interaction is of the form

$$V_{12} = \frac{(A_I(2N_1 - B_1) - A_B B_1)(A_I(2N_2 - B_2) - A_B B_2)g^2}{r} \quad (6)$$

it is positive for like charges. Therefore, the superweak field must be a vector field. Let us develop the basic equations of the classical superweak field. Since the boson is massless, we will arrive at the equations by drawing analogies with electrodynamics. The superweak field is given by

$$\varphi = \frac{Q}{r}. \quad (7)$$

where $Q = (A_I(2N - B) - A_B B)g$. The charge Q may be broken into $Q = Q_B + Q_I$ (I of isospin). Because of the variation of N with time, the charge Q is also a slow function of time governed by the times involved in the transformation of a nucleon into the other. We can, thus, define a generalized superweak current density by

$$\iota^i = (c\varrho, \boldsymbol{\jmath}) \quad (8)$$

which is actually a baryonic current. Because of baryon number conservation, for a closed system, what changes with time is Q_I . Considering that $v \ll c$, $\boldsymbol{\jmath}$ will be $\varrho \mathbf{v}$. In the above formula $\varrho = \frac{A_I(2N - B)g - A_B B g}{V}$, where V is the volume which contains the charges. For a fixed N we also find the equation of continuity

$$\nabla \cdot \boldsymbol{\jmath} + \frac{\partial \varrho}{\partial t} = 0. \quad (9)$$

We may define a 4-vector field, \forall^i , as

$$\forall^i = (\varphi, \forall). \quad (10)$$

In this way we may also define the fields ϵ and \cap given by

$$\epsilon = -\frac{1}{c} \frac{\partial \forall}{\partial t} - \nabla \varphi \quad (11)$$

and

$$\cap = \nabla \times \forall. \quad (12)$$

With the above fields and using the field strength tensor

$$\Pi^{\mu\nu} = \partial^\mu \forall^\nu - \partial^\nu \forall^\mu \quad (13)$$

we obtain

$$\partial_\mu (\epsilon^{\mu\nu\alpha\beta} \Pi_{\alpha\beta}) = 0. \quad (14)$$

As in electrodynamics we may also define a Lagrangian density for the field and for the interaction of the field with the superweak charge, given by

$$\mathcal{L} = -\frac{1}{16\pi} \Pi^{\mu\nu} \Pi_{\mu\nu} - \frac{1}{c} \iota_\alpha \forall^\alpha. \quad (15)$$

In terms of the Lagrangian density we have an action given by

$$S = \int \mathcal{L} d^4x. \quad (16)$$

When we minimize the action S , we arrive at

$$\partial_\nu \Pi^{\mu\nu} = \frac{4\pi}{c} \iota^\mu. \quad (17)$$

Equations (14) and (17) may be written in terms of the potentials as

$$\nabla^2 \varphi + \frac{1}{c} \frac{\partial}{\partial t} (\nabla \cdot \forall) = -4\pi \varrho \quad (18)$$

and

$$\square \forall - \nabla \left(\nabla \cdot \forall + \frac{1}{c} \frac{\partial \varphi}{\partial t} \right) = -\frac{4\pi}{c} j. \quad (19)$$

As in electrodynamics the superweak field may be gauged in several ways. If we choose the Coulomb gauge

$$\nabla \cdot \forall = 0 \quad (20)$$

Eq.(18) satisfies the Poisson equation

$$\nabla \varphi = -4\pi \varrho \quad (21)$$

whose solution is

$$\varphi(\mathbf{x}, t) = \int \frac{\varrho(\mathbf{x}, t)}{(\mathbf{x} - \mathbf{x}')^3} d^3x'. \quad (22)$$

which is an instantaneous potential. Therefore, we may justify the lack of retarded potential effects in the calculations involving the superweak potential among galaxies. If we consider that in stars N (the number of neutrons) increases slowly with time and considering the different cycles of a star we may consider that, for a whole galaxy, N is given by

$$N = N_0(1 - e^{-\frac{t}{\tau}}). \quad (23)$$

Since τ is a very long time, probably, a few billion years, in Eq.(22) the approximation

$$\mathbf{x} - \mathbf{x}' \ll c\tau \quad (24)$$

holds. This means that the static fields may be used.

As we showed above the superstrong interaction should be mediated by three heavy bosons (called mixons). They should have spin 0, and therefore, the superstrong field should be a scalar field. It will become clear in sections X, XI and XII that this interaction is responsible for the creation of mass in quarks and hadrons. Presumably, it may be unified to the gravitational force at $t = 0$. Since we are dealing with a scalar field the Lagrangian density of the superstrong interaction has the general form

$$\begin{aligned} \mathcal{L}_{SS} = & \frac{1}{2}m \int \eta_{\alpha\beta} u^\alpha u^\beta \delta 4x\gamma - z\gamma(\tau) |d\tau \\ & - \frac{1}{8\pi} (\phi_{,\alpha}\phi, \alpha + \mu\phi) - \mathcal{U} \int d\tau \delta 4x\alpha - z\alpha(\tau) | \end{aligned} \quad (25)$$

where $z\alpha(\tau)$ is the world line of primons. The mass m is presumably small (or zero) since the superstrong interaction, together with the strong interaction, are able to generate mass (of quarks and hadrons). If primons have a small mass, such a mass has to be intrinsic, not caused by the superstrong interaction. It may be the same kind of mass that leptons have. The superstrong charge is indicated by \mathcal{U} .

The author will not treat the gravitational field in this work. Such a field seems to be quite elusive. As has been shown (26, 27, 28) it is possible to have a scalar field theory of gravity. It is also possible that the right theory for gravity has not been found yet.

VII. THE S-MATRIX OF THE SUPERWEAK INTERACTION BETWEEN A NEUTRON AND A PROTON

Let us, first, calculate the superweak field produced by a proton. Choosing the Lorentz gauge the superweak potential satisfies Poisson equation

$$\square \forall j(x) = -\frac{4\pi}{c} \iota j(x). \quad (26)$$

In order to find ιj we need to integrate the above equation. We may do it following the footsteps of electrodynamics. First, we define a propagator, \mathcal{D} as(29)

$$\square \mathcal{D}(x - y) = \delta 4(x - y) \quad (27)$$

which has the Fourier representation

$$\mathcal{D}(x - y) = \int \frac{\delta 4k}{2\pi 4} e^{-i\mathbf{k}\cdot(\mathbf{x} - \mathbf{y})} \left(\frac{-1}{k^2 + i\epsilon} \right) \quad (28)$$

where we have added an infinitesimal positive imaginary part to k^2 . The solution for the Poisson equation is, therefore,

$$\forall j(x) = \int d4y \mathcal{D}(x - y) \iota j(y). \quad (29)$$

Choosing for $\iota j(y)$,

$$\iota j(y) = Q_p \bar{\psi} p_f \gamma_j \psi p_i, \quad (30)$$

where $Q_p = -(A_I + A_B)g$, and using plane-wave solutions for free protons and neutrons, we obtain

$$\iota j(y) = -\frac{(A_I + A_B)g}{V} \frac{m_p}{(E_i E_f)^{0.5}} e i (\mathbf{P}_f - \mathbf{P}_i) \cdot \mathbf{y} \bar{u}(P_f, S_f) \gamma_j u(P_i, S_i) \quad (31)$$

and

$$\begin{aligned} S_{fi} &= \frac{i4\pi(A_I 2 - A_B 2)g^2}{cV2} (2\pi) 4 \delta 4(P_f - P_i + p_f - p_i) \frac{m_n}{\sqrt{E_f n E_i n}} \frac{m_p}{\sqrt{E_f p E_i p}} \\ &\times (\bar{u}(p_f, s_f) \gamma_j u(p_i, s_i)) \frac{1}{(p_f - p_i)^2 + i\epsilon} (\bar{u}(P_f, S_f) \gamma_j u(P_i, S_i)). \end{aligned} \quad (32)$$

The above S-matrix element corresponds to the Feynman graph shown below. Therefore, the cross section of the superweak interaction between two protons is $(A_I - A_B)g^2/e^2$ smaller than the electromagnetic interaction between them.

VIII. THE UNIFICATION OF THE SUPERWEAK AND STRONG INTERACTIONS

As was shown in section VI the superweak field satisfies the Poisson equation

$$\square \forall \alpha = -\frac{4\pi}{c} \iota \alpha. \quad (33)$$

As has been shown(25), as $t \rightarrow 0$, $v \rightarrow 0$ and $N \rightarrow Z$ (or $\eta \rightarrow 0.5$). Therefore, $\iota \alpha \rightarrow \iota o = -A_B B g / V$ and $\forall \alpha \rightarrow \forall o = \varphi$. Thus, Eq.(33) becomes

$$\square \varphi = 4\pi \frac{A_B B g}{c V}. \quad (34)$$

Making the substitution $\varphi' = \frac{cV}{A_B B} \varphi$, one obtains

$$\square \varphi' = 4\pi g \quad (35)$$

whose solution, for small r , is indistinguishable from the solution of the equation

$$\square\varphi' - \mu\varphi' = 4\pi g. \quad (36)$$

Therefore, the superweak interaction is unified to the strong interaction at $t = 0$.

Therefore, resuming the results we are able to construct the following table for the interactions of matter:

TABLE OF THE UNIFICATION OF THE FORCES OF NATURE

Weak(3 heavy vector bosons)	with Electromagnetic(1 massless vector boson)
Strong(3 heavy pseudoscalar bosons)	with Superweak(1 vector massless boson)
Superstrong(3 heavy scalar bosons)	with Gravity(1 massless boson) ???

From the above table we may imply that the unitary group of gravity has to be $U(1)$ and that the corresponding boson is massless. A summary of the fundamental interactions of nature is presented in Table 6.

IX. QUARK CONFINEMENT

Quantum chromodynamics(QCD) has been quite successful at providing a simple picture of many processes involving hadrons and leptons. However, many features of QCD remain unanswered. Two of them are quark confinement and the energies of hadrons, including the resonant states. Also, the number of quarks is so high that we may ask if they are elementary, after all. Moreover, QCD lacks a dynamical content.

It has been proposed above that quarks are composed of prequarks which are true elementary particles, together with leptons. It has been shown above that two forces act in the interaction among quarks. These two forces are the strong and the superstrong forces. It has also been suggested that these forces must have opposite signs when acting among quarks.

Present experiments show that quarks are permanently confined inside hadrons, at least, within the energies allowed by the present generation of particle accelerators.

Quark confinement can be explained, based on first principles, as the result of the superstrong and strong interactions together. Because the quark is a structured state it is formed by the action of the superstrong and strong forces. That is, we expect that there should exist an effective attractive potential as we have in the other kinds of structured matter. Therefore, we also expect to have a sort of Lennard-Jones effective potential in the interaction among quarks. Expanding a Lennard-Jones potential around the minimum we obtain

a harmonic oscillator potential. Thus, if we consider that in their lowest state of energy quarks are separated by a distance r_q , then for small departures from equilibrium the potential must be of the form

$$V(r) = V_o + \frac{K}{2}(r - r_q)^2 \quad (37)$$

where K is a constant and V_o is a negative constant representing the depth of the potential well. As r increases the restoring force among quarks also increases. Because of it quarks may be permanently confined.

X. THE ENERGIES OF BARYON STATES (INCLUDING ALL KNOWN RESONANCES)

Around its minimum we may approximate a Lennard-Jones potential by the potential of a harmonic oscillator and include the anharmonicity as a perturbation. By doing so we may be able to calculate the energies of almost all baryon states.

Let us consider a system composed of three quarks which interact in pairs by means of a harmonic potential. Let us disregard the electromagnetic interaction which must be considered as a perturbation. Also, let us disregard any rotational contribution which may enter as a perturbation too. This is reasonable because the strong and superstrong interactions must be much larger than the “centrifugal” potential. If we consider that quarks do not move at relativistic speeds, and disregarding the spin interaction among quarks, we may just use Schrödinger equation in terms of normal coordinates(30)

$$\sum_{i=1}^6 \frac{\partial^2 \psi}{\partial \xi_i^2} + \frac{2}{\hbar^2} \left(E - \frac{1}{2} \sum_{i=1}^6 6\omega_i \xi_i^2 \right) \psi = 0 \quad (38)$$

where we have used the fact that the three quarks are always in a plane. The above equation may be resolved into a sum of 6 equations

$$\frac{\partial^2 \psi}{\partial \xi_i^2} + \frac{2}{\hbar^2} \left(E_i - \frac{1}{2} \omega_i \xi_i^2 \right) \psi = 0, \quad (39)$$

which is the equation of a single harmonic oscillator of potential energy $\frac{1}{2}\omega_i \xi_i^2$ and unitary mass with

$$E = \sum_{i=1}^6 6E_i. \quad (40)$$

The general solution is a superposition of 6 harmonic motions in the 6 normal coordinates.

The eigenfunctions $\psi_i(\xi_i)$ are the ordinary harmonic oscillator eigenfunctions

$$\psi_i(\xi_i) = N_{v_i} e^{-(\alpha_i/2)\xi_i^2} H_{v_i}(\sqrt{\alpha_i}\xi_i), \quad (41)$$

where N_{v_i} is a normalization constant, $\alpha_i = \nu_i/\hbar$ and $H_{v_i}(\sqrt{\alpha_i}\xi_i)$ is a Hermite polynomial of the v_i th degree. For large ξ_i the eigenfunctions are governed by the exponential functions which make the eigenfunctions go to zero very fast. Of course, *this is valid for any energy and must be the reason behind quark confinement*. We will come back yet to this point after calculating the possible energy levels of baryons.

The energy of each harmonic oscillator is

$$E_i = \hbar\nu_i(v_i + \frac{1}{2}), \quad (42)$$

where $v_i = 0, 1, 2, 3, \dots$ and ν_i is the classical oscillation frequency of the normal “vibration” i , and v_i is the “vibrational” quantum number. The total energy of the system can assume only the values

$$E(v_1, v_2, v_3, \dots, v_6) = \hbar\nu_1(v_1 + \frac{1}{2}) + \hbar\nu_2(v_2 + \frac{1}{2}) + \dots + \hbar\nu_6(v_6 + \frac{1}{2}). \quad (43)$$

As was said above the three quarks in a baryon must always be in a plane. Therefore, each quark is composed of two oscillators and so we may rearrange the energy expression as

$$E(n, m, k) = \hbar\nu_1(n + 1) + \hbar\nu_2(m + 1) + \hbar\nu_3(k + 1), \quad (44)$$

where $n = v_1 + v_2, m = v_3 + v_4, k = v_5 + v_6$. Of course, n, m, k can assume the values, 0, 1, 2, 3, ... We may find the constants $\hbar\nu$ from the ground states of some baryons. They are the known quark masses taken as $m_u = m_d = 0.31\text{Gev}$, $m_s = 0.5\text{Gev}$, $m_c = 1.7\text{Gev}$ and $m_b = 5\text{Gev}$. The mass of the top quark has not been determined yet, but as we will show the present theory may help in the search for its mass.

Let us start the calculation with the states ddu(neutron), uud(proton) and ddd(Δ^-), uuu (Δ^{++}) and their resonances. All the energies below are given in Gev. The experimental values of baryon masses were taken from reference 31. Because $m_u = m_d$, we have that the energies calculated by the formula

$$E_{n,m,k} = 0.31(n + m + k + 3) \quad (45)$$

correspond to many energy states. Some levels contain an “intrinsic” pion excitation and their energies are the sum of the energy of the previous level plus a pion energy. This happens whenever the difference between any two levels is of the order of 280MeV. This fact induces, somehow, one or more levels between the two levels. Of course, this is completely ad hoc at this point and needs further investigation. Some levels may also be caused by the three-fold degeneracy which may be raised if we take into account the anharmonicity of the potential. As we can conclude from the experimental values this contributes roughly a pion mass. Further splitting is expected(as with the other regular levels $E_{n,m,k}$) due to electromagnetic and weak interactions. The state $E_{0,0,0} + \pi$ should not be allowed, somehow, because there is no level located at 1.07Gev. The justification for the omission of this level will have to wait for the understanding of the superstrong interaction, but it may be related to the stability of the proton which is the state $E_{0,0,0}$. The calculated values are displayed in Table 7.

For the Ξ particle the energies are expressed by

$$E_{n,m,k} = 0.31(n + 1) + 0.5(m + k + 2). \quad (46)$$

See Table 8 to check the agreement with the experimental data.

In the same way the energies of Ω are obtained by

$$E_{n,m,k} = 0.5(n + m + k + 3). \quad (47)$$

Again, there are energies given by $E_{n,m,k} + \pi$. The energies are displayed in Table 9. The discrepancies are higher, of the order of 10% and decreases as the energy increases. This is a tendency which is also observed for the other particles. This may mean that, at the bottom, the potential is flatter than the potential of harmonic oscillator. That is, the effective potential must have terms of fourth order or higher order terms. As the energy increases the potential becomes closer to the one of a harmonic oscillator.

In the same fashion we list below the formulas for calculating the energies of many other states. The energies of the charmed baryons($C = +1$) $\Lambda_c +$, $\Sigma_c +$, $\Sigma_c +$ and $\Sigma_c 0$ are given by

$$E_{n,m,k} = 0.31(n + m + 2) + 1.7(k + 1). \quad (48)$$

The levels are shown on Table 10. For the charmed baryons($C = +1$) $\Xi_c +$ and $\Xi_c 0$ we have

$$E_{n,m,k} = 0.31(n + 1) + 0.5(m + 1) + 1.7(k + 1). \quad (49)$$

The results are displayed on Table 11. As for the $\Omega_c 0$, its energies are

$$E_{n,m,k} = 0.5(n + m + 2) + 1.7(k + 1). \quad (50)$$

Table 12 shows the energy levels results.

We may predict the energies of many particles given by the formulas:

- ucc and dcc, $E_{n,m,k} = 0.31(n + 1) + 1.7(m + k + 2)$;
- scc, $E_{n,m,k} = 0.5(n + 1) + 1.7(m + k + 2)$;
- ccc, $E_{n,m,k} = 1.7(n + m + k + 3)$;
- ccb, $E_{n,m,k} = 1.7(n + m + 2) + 5(k + 1)$;
- cbb, $E_{n,m,k} = 1.7(n + 1) + 5(m + k + 2)$;
- ubb and dbb, $E_{n,m,k} = 0.31(n + 1) + 5(m + k + 2)$;
- uub and ddb, $E_{n,m,k} = 0.31(n + m + 2) + 5(k + 1)$;
- bbb, $E_{n,m,k} = 5(n + m + k + 3)$.

We clearly see from Tables 7,8,9,10,11,12 and 13 that there are minor discrepancies in some states between the calculated energy and the experimental data. This is expected because of the assumptions that we made. An improved model must include the electromagnetic interaction, the effect of rotation(or spin) and the isospin. All of them will split the levels. Also, we must include the anharmonicity of the potential. The present treatment assumed that the oscillators are independent. But, this may not be the case and there must exist coupling between them.

From the above discussion we see clearly that it is meaningless to try to make quarks free by using more energetic collisions between two baryons because we will just get more excited states. That is, we will obtain more and more resonances. This is so because, as shown above, as the separation between two quarks increases the wavefunction vanishes very fast regardless of the state of energy.

According to our considerations the total mass of a baryon must be given by

$$M = M_K + V_{S,SS} + V_e + V_{spin} \quad (51)$$

where M_K is the total kinetic energy of the three constituent quarks, $V_{S,SS}$ is the potential of the combination of the strong and superstrong interactions(our Lennard-Jones potential), V_e is the electromagnetic interaction, and V_{spin} is the spin dependent term of the mass. We showed above that $V_{S,SS}$ is the leading term. Since quarks have charges the term V_e must contribute in the splitting of the levels. Therefore, we conclude that M_K must be very small. As is argued

by Lichtenberg³² it is hard to see how $SU(6)$ is a good approximate dynamical symmetry of baryons if quarks move at relativistic velocities inside baryons. As has been shown by Morpurgo³³ a nonrelativistic approximation might be a good one. Our treatment above agrees well with this conclusion since we used Schrödinger's equation for the oscillators.

We see that the masses of baryons are described quite well by the simple model above described. It lends support to the general framework of having quarks as the basic building particles of baryons. Therefore, it agrees well with QCD. But, the model is also based on the idea of having a substructure for quarks, i.e., a superstrong interaction which may be the interaction responsible for the masses of quarks. We also have shown that quarks may be permanently confined inside baryons. The model needs, of course, further developments in order to include the electromagnetic interaction and the contributions of the spin and isospin to the mass.

XI. THE EXCITED STATES OF QUARKS

The interaction between two primons brings forth the action of the strong force between them, and there is also the action of the superstrong interaction between them. Therefore, there is a sort of effective potential energy which can be approximated by a Lennard-Jones potential energy. This potential energy is harmonic around its minimum. Considering that primons do not move at relativistic speeds and doing in the same fashion as we did in section X we obtain that the masses of quarks should be given by

$$E_q = \bar{\hbar}\nu(k + 1/2) \quad (52)$$

in which $k = 0, 1, 2, 3, \dots$ and $\bar{\hbar}$ has been previously defined.

Let us now determine the energy levels of the quarks u,d,s,c,t and b. The ground state of the u quark is about 0.31GeV. Therefore, $\bar{\hbar}\nu = 0.62$ GeV. Thus, the energies of the u and d quarks are 0.31GeV, 0.93GeV, 1.55GeV, 2.17GeV, ... Making the same for the other quarks we obtain the following results:

- $E_u = E_d = 0.62(k + 1/2)$;
- $E_s = 1(k + 1/2)$;
- $E_c = 3.4(k + 1/2)$;
- $E_b = 10(k + 1/2)$;
- $E_t = \bar{\hbar}\nu_t(k + 1/2)$.

Since $k + 1/2$ is a half integer, we may also write E_q as

$$E_q = E_o l \quad (53)$$

where l is an odd integer. The calculated values are shown on Table 14.

Due to the overtones of the vibrations in the effective potential energy there must also exist other energy levels. For example, the overtones of the ground state with all the other excited states for the u and d quarks produce the energy levels 1.24GeV, 1.86GeV, 2.48GeV, etc. In the same way for the s quark one obtains 2.0GeV, 3.0GeV, 4.0GeV, etc. We can easily see that the higher overtones coincide either with the regular levels or with the overtones of the ground state.

Because quarks are confined we could observe the excited levels only by means of hadrons, but actually we can not. The reason is simple. Let us, for example, consider the baryons made of the first excited states of the u or d quarks. According to Eq.(44) such baryons have energies

$$\begin{aligned} E*_{111u} &= E*_{111d} = 0.93(n+1) + 0.93(m+1) + 0.93(k+1) \\ &= 0.93(n+m+k+3) \end{aligned} \quad (54)$$

in which the asterisk means excited state and the repeated ones mean that each quark is in the first excited state. But $0.93(n+m+k+3) = 0.31(3(n+m+k)+9)$ can be represented as $0.31(n'+m'+k'+3)$, where n' , m' , and k' are also integers that satisfy the relation

$$n' + m' + k' = 3(n + m + k + 2). \quad (55)$$

Therefore, the baryons made of quark excited states cannot be observed because their energy levels coincide with the energies of baryons made of quark ground states. The same also happens for the overtones.

XII. THE ENERGIES OF MESONS

According to QCD a meson is a colorless state which transforms under SU_3 as

$$q_{in}q_{jn} = \bar{q}_{in}q_{jn}. \quad (56)$$

According to the theory presented above it is reasonable to admit that there is also a harmonic effective potential energy in the interaction between a quark and an antiquark. As we know they are also confined inside mesons, which,

actually, supports the ideas above. In this fashion the energies of many mesons should be given by

$$E_n = \hbar\nu(n + 1/2). \quad (57)$$

Let us apply it to the pion family. The ground state must correspond to the three pions $\pi+$, $\pi-$ and $\pi0$. The splitting comes from the electromagnetic interaction (and from the anharmonicity of the potential energy). What to choose for $\hbar\nu_\pi$? We know that it is in the range 270-280 MeV. The values of the corresponding energies are shown in Table 15. The levels have been labeled as π_n . There is a good agreement for almost all levels (error below 3%). The level with energy between 405 and 420 MeV is forbidden, somehow. The experimental values were taken from reference 31, except the energy of the ϵ meson, which was taken from reference 34. We may predict that there must exist mesons of the pion family with energies between 2565 and 2660 MeV. Of course, many levels should come from the inumerous overtones of the ground state with all the other excited states. For example, the $f_o(1400\text{MeV})$ meson is just the overtone π_{0+4} . All the other levels can be identified in the same way. The results are summarized on Table 16.

The energies of the other mesons are calculated in the following way: There are levels, called regular levels, which follow Eq. (57), and there are levels that are overtones of the regular levels with the pion levels. This means that the net potential (of the superstrong and strong interaction) also generates pion mass oscillations. This is justified in quantum mechanics if we assume that the hamiltonian H can be broken in two parts, one of the given meson and the other of the pion, i.e.,

$$H\Psi = (H_M + H_\pi)\Psi = E\Psi = (E_M + E_\pi)\Psi \quad (58)$$

where H_M is the hamiltonian of a given meson and H_π is the hamiltonian of the pion. The wavefunction $\Psi = \Psi_M\Psi_\pi$, in which Ψ_M is the meson wavefunction and Ψ_π is the wavefunction of a pion state. Therefore, the energy E is just

$$E = \hbar\nu_M(n + \frac{1}{2}) + \hbar\nu_\pi(k + \frac{1}{2}). \quad (59)$$

Adding the overtones of the pion family we also have that many levels will be given by

$$E = \hbar\nu_M(n + \frac{1}{2}) + \hbar\nu_\pi(k + \frac{1}{2}) + \hbar\nu_\pi(m + \frac{1}{2}). \quad (60)$$

The first levels are for $n = 0$, $m = 0$, and any value of k . We should keep in mind that any wavefunction that we are considering is the spatial part of the total

wavefunction. The other part of it is due to isospin and has not been considered in this work. For the K meson let us take $\hbar\nu_K=996\text{MeV}$. The regular energy levels, K_n are 498MeV, 1494MeV, 2490MeV, etc. Many other states are the overtones of pion states with K_0 . These results mean that the excited states of kaons are not pure $\bar{s}u$, $\bar{s}d$ states, but should also contain pion states, which here are represented by $\bar{u}u$. The results are listed on Tables 17 and 18. For energies higher than about 1629MeV we have the overtones of K_1 with the pion states. These have not been included in the tables because it becomes very difficult to know if a given state belongs to first array of overtones or to the second one. This will have to wait for the knowledge of the selection rules that we should follow.

Let us, now, consider the D mesons. We have $\hbar\nu_D = 3728\text{MeV}$. The regular levels according to Eq.(134) are 1864MeV, 5592MeV, 9320MeV, etc. The ground state overtones are 7456MeV, 11184MeV, etc. The observed states D^* , D_1 and D_{*2} are just overtones of the ground states with pion states. That is, $D^*(2010) = D_0(1864) + \pi_0(140)$; $D_1(2420) = D_0(1864) + \pi_{0+1}(540 - 560)$. Tables 19 and 20 show these results.

In the same fashion for D_S mesons, $\hbar\nu_{D_S} = 3938\text{MeV}$. The regular energy levels are 1968MeV, 5907MeV, 9845MeV, etc. The ground state overtones are 7875MeV, 11813MeV, etc. The states D_{*S} and D_{S1} are overtones of the ground state with pion states, i.e., $D_{*S}(2110) = D_{S(0)}(1969) + \pi_0(140)$; $D_{S1}(2536) = D_{S(0)}(1969) + \pi_{0+1}(540 - 560)$. The levels are found on Tables 21 and 22.

Only the ground state of the B meson has been observed experimentally. Expecting that it follows the same general trend shown above we may predict the possible excited states(Tables 23 and 24).

The $c\bar{c}$ mesons may be treated in the same way if we consider that $\eta_c(2980)$ is the ground state. Table 25 shows the regular states calculated according to $\hbar\nu_{c\bar{c}}(n + 0.5)$ with $\hbar\nu_{c\bar{c}} = 5960\text{MeV}$. The other excited states are the overtones of $\eta_c(2980)$ with pion states. For instance, $\chi_{c0}(3415)$ is the overtone $\eta_c(2980) + \pi_1(405 - 420)$. In the same fashion we have that $\chi_{c2}(3556) = \eta_c(2980) + \pi_{0+1}(540 - 560)$. The calculated values are listed on Table 26.

The energies of the regular states of $b\bar{b}$ are given by $\hbar\nu_{b\bar{b}}(n + 0.5)$ with $\hbar\nu_{b\bar{b}} = 18920$. The other excited states of the $b\bar{b}$ mesons follow the same trend of the heavy mesons, that is, they are just overtones of the ground state $\Upsilon(9460)$ with pion states. One state(and possibly others to be found), however, is a superposition of the ground state with an excited state of the kaon. It is the state $\Upsilon(10355) = \Upsilon(9460) + K_0(498) + \pi_1(405 - 420)$. Some examples of the other states are $\chi_{b0}(9860) = \Upsilon(9460) + \pi_1(405 - 420)$; $\Upsilon(10023) = \Upsilon(9460) + \pi_{0+1}(540 - 560)$; $\chi_{b2}(10270) = \Upsilon(9460) + \pi_{0+2}(810 - 840)$. All states are listed on Tables 27 and 28.

Of course, for all mesons we may predict the possible values of the energies of many levels to be found experimentally. We observe that some overtones do not occur. At this point there is no explanation for this fact. Of course, it may be so because of selection rules yet to be found.

According to the above theory the largest contribution to the masses of hadrons (and of quarks) comes from the strong and superstrong interactions (together). But, what about the energies of leptons? We can immediately see that the masses of the electron, muon and τ do not correspond to the levels of a harmonic oscillator. This is in a certain way in agreement with what was said in the beginning of this work, because we found that leptons should belong to a separate class and must be elementary particles, just as primons are. If this theory is true the Higgs scalar field does not exist at all. All experiments up to now show exactly this. Its mass has been searched in many different ranges and has not been found. As this paper shows we will have to modify QCD, by including the dynamical part that it lacks.

In the light of what was shown above, we can understand the different decay channels of mesons into kaons or into pions. For example, the meson $a_0(983)$ is either $K_0 + \pi_{0+1}$ or $\pi_3(945 - 980)$. Therefore, we expect that it will decay into kaons or into pions. In the same way, we expect f_0 to decay as $K\bar{K}$ and as $\eta\rho$. The $f_2(1270)$ meson may be either $K_0 + \pi_{0+2}$ or $\pi_4(1215 - 1260)$. Thus, it will decay into $\pi\pi$ and $K\bar{K}$. Its decay $\eta\eta$ is a consequence of the decay $\pi\pi$. This is also the case for many other mesons. According to Table 18 $\omega(1594)$ (or another resonance with about the same energy) will also have a decay mode involving kaons.

XIII. CONCLUSION

It is proposed that nature has six fundamental forces which are unified in pairs and, therefore, reduced to three at $t = 0$. Some general ideas concerning the characteristics of the superstrong interaction have been presented. The superweak interaction is responsible for the expansion and contraction of the Universe. It is shown that it is unified with the strong force at $t = 0$.

A reasonable physical explanation for quark confinement is provided. The energies of all hadrons including all known resonances are calculated in a simple manner. The energies of all other hadrons to be discovered are given. The excited states of quarks have also been calculated and has been shown why they can not be observed. The paper predicts the existence of three heavy bosons of the superstrong interaction and a massless boson of the superweak interaction. It is proposed that the gauge group of gravity is $U(1)$.

The evidence of the superstrong interaction is obvious from the calculated values of the energies of hadrons. The non-existence of the Higgs boson also gives support to the existence of a superstrong interaction.

It has been shown that the superweak force is unified to the strong force at $t = 0$.

References

1. A. A. Penzias and R. W. Wilson, *Astrophys. J.* **142**, 419(1965).
2. J. C. Mather, Cheng,E.S., Eplee,R.E., Isaacman,R.B., Meyer,S.S., Shafer,R.A., Weiss,R., Wright,E.L., Bennet,C.L., Boggess,N.W., Dwek,E., Gulkis,S., Hauser,M.G., Janssen,M., Kelsall,T., Lubin,P.M., Moseley,Jr.,S.H., Murdock,T.L., Siverberger,R.F., Smoot,G.F.,and Wilkinson,D.T., *Astrophys. J.(Letters)* **354**, L37(1990).
3. E. Hubble, in *Proceedings of the National Academy of Science*, **15**,168-173(1929).
4. J. C. Mather, talk at the XIII Interantional Conference on General Relativity and Gravitation, Huerta Grande, Argentina, 1992.
5. V. de Lapparent, M. J. Geller, and J. P. Huchra, *Astrophys. J.(Letters)* **302**, L1(1986).
6. T. J. Broadhurst, R. S. Ellis, D. C. Koo, and A. S. Szalay, *Nature* **343**,726(1990).
7. A. Dressler and S. M. Faber, *Astrophys. J.* **354**, 13(1990).
8. A. Dressler, S. M. Faber, D. Burnstein, R. L. Davies, D. Lynden-Bell, R. J. Terlevich, and G. Wegner, *Astrophys. J.(Letters)* **313**, L37(19)
9. D. Lynden-Bell, S. M. Faber, D. Burnstein, R. L. Davies, A. Dressler, R. J. Terlevich, and G. Wegner, *Astrophys. J.* **326**, 19(1988).
10. H. Kurki-Suonio, G. J. Mathews, and G. M. Fuller, *Astrophys. J.(Letters)* **356**, L5(1990).
11. S. J. Maddox, G. Efstathiou, W. J. Sutherland and J. Loveday, *Mon. Not.Astr.Soc.* **242**, 43p(1990).
12. W. Saunders. M. Rowan-Robinson, and A. Lawrence, “The Spatial Correlation Function of IRAS Galaxies on Small and Intermediate Scales”, 1992, QMW preprint.
13. G. B. Dalton, G. Efstathiou, S. J. Maddox, and W. J. Sutherland, *Astrophys. J. Lett.* **390**, L1, 1992.
14. M. S. Vogeley, C. Park, M. J. Geller, and J. P. Huchra, *Astrophys. J. Lett.* **391**, L5, 1992.
15. C. Park, J. R. Gott, and L. N. da Costa, *Astrophys. J. Lett.* **392**, L51, 1992.
16. M. Rowan-Robinson, *New Scientist* **1759**, 30(1991).
17. W. Saunders, C. Frenk, M. Rowan-Robinson, G. Efstathiou, A. Lawrence, N. Kaiser, R. Ellis, J. Crawford, X.-Yang Xia and I. Parry, *Nature* **349**, 32(1991).
18. S. White, talk at the XIII International Conference on General Relativity and Gravitation, Huerta Grande, Argentina, 1992.
19. H. Fritzsch, in *Proceedings of the twenty-second Course of the International School of Subnuclear Physics, 1984*, ed. by A. Zichichi (Plenum Press, New York, 1988).
20. W. Küpper, G. Wegmann, and E. R. Hilf, *Ann. Phys.* **88**, 454(
21. D. Bandyopadhyay, J. N. De, S. K. Samaddar, and D. Sperber, *Phys. Lett. B* **218**, 391.
22. J. E. Lennard-Jones, *Proc. Roy. Soc. A***106**, 463(1924).
23. K. Huang, in *Quarks, Leptons and Gauge Fields*(World Scientific, Singapore, 1982).

24. G. 'tHooft, in *Recent Developments in Gauge Theories*, eds. G. 'tHooft et al.(Plenum Press, New York, 1980).
25. M. E. de Souza, in *On the General Properties of Matter*, report no. MES-02-092493, September 1993.
26. C. Brans and R. H. Dicke, *Phys. Rev.* **124**, 925(1961).
27. P. Jordan, *Z. Phys.* **157**, 112(1959).
28. W.-T. Ni, *Astrophys. J.* **176**, 769(1972).
29. J. D. Bjorken and S. D. Drell, in *Relativistic Quantum Mechanics* (McGraw-Hill, New York, 1964).
30. L. Pauling and E. B. Wilson Jr., *Introduction to Quantum Mechanics* (McGraw-Hill, New York, 1935).
31. Particle Data Group, *Review of Particle Properties*, *Phys. Rev. D*, **45**, Part II, No. 11 (1992).
32. Lichtenberg, D. B., *Unitary Symmetry and Elementary Particles* (Academic Press, New York, N.Y) 1970.
33. Morpurgo, G., *14th International Conference on High Energy Physics*, Vienna, p.225. CERN, Geneva.
34. *Review of Particles Properties*, *Rev. Modern Phys.*, **45**, Suppl., 1973.

?	quark	nucleon
nucleon	nucleus	atom
atom	gas	galaxy
	liquid	
	solid	
galaxy	galactic liquid	?

Table 1. The two general states which make everything in the Universe, stepwise. The table is arranged in such a way to show the links between the polarized states and the single states.

?	?	strong force
strong force	strong force	electromagnetic force
	electromagnetic force	
electromagnetic force	electromagnetic force	gravitational force
	gravitational force	
gravitational force	?	?

Table 2. Three of the fundamental forces of nature. Each force appears twice and is linked to another force by means of a correlated state. The interrogation marks suggest that there should exist two other forces. Compare with Table 1.

superflavor	charge	spin
p_1	$\frac{5}{6}$	$\frac{1}{2}$
p_2	$-\frac{1}{6}$	$\frac{1}{2}$
p_3	$-\frac{1}{6}$	$\frac{1}{2}$
p_4	$-\frac{1}{6}$	$\frac{1}{2}$

Table 3. Table of charges and spins of primons.

p_1	p_2	p_3	p_4
p_1	u	s	t
p_2	u	d	c
p_3	s	d	b
p_4	t	c	b

Table 4. Table of composition of quark flavors.

α	β	γ
α	blue	green
β	blue	red
γ	green	red

Table 5. Table of the generation of colors out of the supercolors.

Interaction	Superstrong	Strong	Electromagnetic	Gravity
Static potential	$\frac{\mathcal{U}_1 \mathcal{U}_2}{4\pi r} e - \mu r?$ $\frac{\hbar}{\mu c} < 10-17 \text{cm}$	$-\frac{\sqrt{g}\sqrt{g}}{4\pi r} e - \mu r$ $\frac{\hbar}{\mu c} \sim 10-13 \text{cm}$	$\frac{q_1 q_2}{4\pi r} e - \mu r$ $\mu = 0$	$-\gamma \frac{m_1 m_2}{r} e - \mu r$ $\mu = 0$
Coupling	$\frac{\mathcal{U}_1 \mathcal{U}_2}{4\pi \hbar c} > 104$	$\frac{g^2}{4\pi \hbar c} \approx 10$	$\frac{e^2}{4\pi \hbar c} = \frac{1}{137.036}$	$\frac{\gamma m_p^2}{\hbar c} = 5.76 \times 10^{-36}$ $m_p = \text{proton mass}$
Bosons	$\mathbb{N}_1, \mathbb{N}_2, \mathbb{N}_3$	$\pi+, \pi-, \pi0$	photon	graviton

Table 6. The Six Interactions of Nature. The charge of matter which produces the superstrong interaction among prequarks is represented by \mathcal{U} . Fermi constant is given by Λ . All units are in the CGS system.

Superweak	Weak
$\frac{Q_1 Q_2}{r} e - \mu r$	none
$\mu = 0$	
$A_B, A_I \approx 10^{-67}$	$\Lambda m_p 2 = 1.01 \times 10^{-5}$
symmetron	$W+, W-, Z0$

n, m, k	$E_C(Gev)$	$E_M(\text{Gev})$	Error(%)	$L_{2I.2J}$
0,0,0	0.93	0.938(N)	0.9	P_{11}
$n + m + k = 1$	1.24	1.232(Δ)	0.6	P_{33}
$1.24 + \pi$	1.38	1.44(N)	4.3	P_{11}
$n + m + k = 2$	1.55	1.52(N)	1.9	D_{13}
$n + m + k = 2$	1.55	1.535(N)	1.0	S_{11}
$n + m + k = 2$	1.55	1.6(Δ)	3.1	P_{33}
$n + m + k = 2$	1.55	1.62(Δ)	4.5	S_{31}
$1.55 + \pi$	1.69	1.65(N)	2.4	S_{11}
$1.55 + \pi$	1.69	1.675(N)	0.9	D_{15}
$1.55 + \pi$	1.69	1.68(N)	0.6	F_{15}
$1.55 + \pi$	1.69	1.70(N)	0.6	D_{13}
$1.55 + \pi$	1.69	1.70(Δ)	0.6	D_{33}
$1.55 + \pi$	1.69	1.71(N)	1.2	P_{11}
$1.55 + \pi$	1.69	1.72(N)	1.8	P_{13}
$n + m + k = 3$	1.86	1.90(N)	2.2	P_{13}
$n + m + k = 3$	1.86	1.90(Δ)	2.2	S_{31}
$n + m + k = 3$	1.86	1.905(Δ)	2.4	F_{35}
$n + m + k = 3$	1.86	1.91(Δ)	2.7	P_{31}
$n + m + k = 3$	1.86	1.92(Δ)	3.2	P_{33}
$1.86 + \pi$	2.00	1.93(Δ)	3.5	D_{35}
$1.86 + \pi$	2.00	1.94(Δ)	3.0	D_{33}
$1.86 + \pi$	2.00	1.95(Δ)	2.5	F_{37}
$1.86 + \pi$	2.00	1.99(N)	0.5	F_{17}
$1.86 + \pi$	2.00	2.00(N)	0	F_{15}
$1.86 + \pi$	2.00	2.00(Δ)	0	F_{35}

n, m, k	$E_C(Gev)$	$E_M(Gev)$	Error(%)	$L_{2I.2J}$
$n + m + k = 4$	2.17	$2.08(N)$	4.1	D_{13}
$n + m + k = 4$	2.17	$2.09(N)$	3.7	S_{11}
$n + m + k = 4$	2.17	$2.10(N)$	3.2	P_{11}
$n + m + k = 4$	2.17	$2.15(\Delta)$	0.9	S_{31}
$n + m + k = 4$	2.17	$2.19(N)$	0.9	G_{17}
$n + m + k = 4$	2.17	$2.20(N)$	1.4	D_{15}
$n + m + k = 4$	2.17	$2.20(\Delta)$	1.4	G_{37}
$n + m + k = 4$	2.17	$2.22(N)$	2.3	H_{19}
$2.17 + \pi$	2.31	$2.25(N)$	2.6	G_{19}
$2.17 + \pi$	2.31	$2.3(\Delta)$	0.4	H_{39}
$2.17 + \pi$	2.31	$2.35(\Delta)$	1.7	D_{35}
$n + m + k = 5$	2.48	$2.39(\Delta)$	3.6	F_{37}
$n + m + k = 5$	2.48	$2.40(\Delta)$	3.2	G_{39}
$n + m + k = 5$	2.48	$2.42(\Delta)$	2.4	$H_{3,11}$
$2.48 + \pi$	2.62	$2.60(N)$	0.8	$I_{1,11}$
$n + m + k = 6$	2.79	$2.7(N)$	3.2	$K_{1,13}$
$n + m + k = 6$	2.79	$2.75(\Delta)$	1.4	$I_{3,13}$
$2.79 + \pi$	2.93	$2.95(\Delta)$	0.7	$K_{3,15}$
$n + m + k = 7$	3.10	to be found	?	?
...

Table 7. Baryon states N and Δ . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.31(n + m + k + 3) + lm_\pi$, where l is either 0 or 1. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)	$L_{I,2J}$
0,0,0	1.12	1.116(Λ)	0.4	P_{01}
0,0,0	1.12	1.193(Σ)	6.5	P_{11}
$n + m = 1, k=0$	1.43	1.385(Σ)	3.2	P_{13}
$n + m = 1, k=0$	1.43	1.405(Λ)	1.7	S_{01}
$n + m = 1, k=0$	1.43	1.48(Λ)	3.5	?
0,0,1	1.62	1.52(Λ)	6.2	D_{03}
0,0,1	1.62	1.56(Σ)	3.7	?
0,0,1	1.62	1.58(Σ)	2.5	D_{13}
0,0,1	1.62	1.60(Λ)	1.2	P_{01}
0,0,1	1.62	1.62(Σ)	0	S_{11}
0,0,1	1.62	1.66(Σ)	2.5	P_{11}
0,0,1	1.62	1.67(Σ)	3.1	D_{13}
0,0,1	1.62	1.67(Λ)	3.1	S_{01}
$n + m = 2, k=0$	1.74	1.69(Λ)	2.9	D_{03}
$n + m = 2, k=0$	1.74	1.69(Σ)	2.9	?
$n + m = 2, k=0$	1.74	1.75(Σ)	0.6	S_{11}
$n + m = 2, k=0$	1.74	1.77(Σ)	1.7	P_{11}
$n + m = 2, k=0$	1.74	1.775(Σ)	2.0	D_{15}
$n + m = 2, k=0$	1.74	1.80(Λ)	3.4	S_{01}
$n + m = 2, k=0$	1.74	1.81(Λ)	4.0	P_{01}
$n + m = 2, k=0$	1.74	1.82(Λ)	4.6	F_{05}
$n + m = 2, k=0$	1.74	1.83(Λ)	5.2	D_{05}
$n + m = 1, k=1$	1.93	1.84(Σ)	4.7	P_{13}
$n + m = 1, k=1$	1.93	1.88(Σ)	2.6	P_{11}
$n + m = 1, k=1$	1.93	1.89(Λ)	2.1	P_{03}
$n + m = 1, k=1$	1.93	1.915(Σ)	0.8	F_{15}
$n + m = 1, k=1$	1.93	1.94(Σ)	0.5	D_{13}

State(n, m, k)	E_C (GeV)	E_M (GeV)	Error(%)	$L_{2I,2J}$
$n + m = 3, k=0$	2.05	2.00(Λ)	2.5	?
$n + m = 3, k=0$	2.05	2.00(Σ)	2.4	S_{11}
$n + m = 3, k=0$	2.05	2.02(Λ)	1.5	F_{07}
$n + m = 3, k=0$	2.05	2.03(Σ)	1.0	F_{17}
$n + m = 3, k=0$	2.05	2.07(Σ)	1.0	F_{15}
$n + m = 3, k=0$	2.05	2.08(Σ)	1.5	P_{13}
0,0,2	2.12	2.10(Σ)	0.9	G_{17}
0,0,2	2.12	2.10(Λ)	0.9	G_{07}
0,0,2	2.12	2.11(Λ)	0.5	F_{05}
$m + n = 2, k=1$	2.24	2.25(Σ)	0.5	?
$n + m = 4, k=0$	2.36	2.325(Λ)	1.5	D_{03}
$n + m = 4, k=0$	2.36	2.35(Λ)	0.4	?
$n + m = 1, k=2$	2.43	2.455(Λ)	1.0	?
$n + m = 3, k=1$	2.55	2.585(Λ)	1.4	?
0,0,3	2.62	2.62(Σ)	0	?
$n + m = 5, k=0$	2.67	to be found	?	?
$n + m = 2, k=2$	2.74	to be found	?	?
$n + m = 4, k=1$	2.86	to be found	?	?
$n + m = 1, k=3$	2.93	to be found	?	?
$n + m = 6, k=0$	2.98	3.00(Σ)	0.7	?
$n + m = 3, k=2$	3.05	to be found	?	?
$n + m = 0, k=4$	3.12	to be found	?	?
$n + m = 5, k=1$	3.17	3.17(Σ)	0	?
$n + m = 2, k=3$	3.24	to be found	?	?
...

Table 8. Baryon states Σ and Λ . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.31(n + m + 2) + 0.5(k + 1)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able to predict the energy levels of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)	$L_{2I,2J}$
0,0,0	1.31	1.318	0.6	P_{11}
1,0,0	1.62	1.53	5.6	P_{13}
1,0,0	1.62	1.62	0	?
1,0,0	1.62	1.69	4.3	?
$n=0, m + k = 1$	1.81	1.82	0.6	D_{13}
2,0,0	1.93	1.95	1.0	?
$n=1, m + k = 1$	2.12	2.03	4.2	?
$n=1, m + k = 1$	2.12	2.12	0	?
$n=3, m = k = 0$	2.24	2.25	0.5	?
$n=0, m + k = 2$	2.31	2.37	2.6	?
$n=2, m + k = 1$	2.43	to be found	?	?
$n=4, m = k = 0$	2.55	2.5	2.0	?
$n=1, m + k = 2$	2.62	to be found	?	?
...

Table 9. Baryon states Ξ . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.31(n + 1) + 0.5(m + k + 2)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)
0,0,0	1.5	1.675	11.7
$n + m + k = 1$	2.0	2.25	12.5
$2.0 + \pi$	2.14	2.38	11.2
$n + m + k = 2$	2.5	2.47	1.2
$2.5 + \pi$	2.64	to be found	?
$n + m + k = 3$	3.0	to be found	?
...

Table 10. Baryon states Ω . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.5(n + m + k + 3)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)
0,0,0	2.32	2.285(Λ_c)	1.5
0,0,0	2.32	2.455(Σ_c)	5.8
$n + m = 1$, k=0	2.63	to be found	?
$n + m = 2$, k=0	2.94	to be found	?
...

Table 11. Baryon states Λ_c and Σ_c . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.31(n + m + 2) + 1.7(k + 1)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)
0,0,0	2.51	2.47	1.6
1,0,0	2.82	to be found	?
0,1,0	3.01	to be found	?
...

Table 12. Baryon states Ξ_c . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.31(n+1) + 0.5(m+1) + 1.7(k+1)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n, m, k)	E_C (Gev)	E_M (Gev)	Error(%)
0,0,0	2.7	to be found	?
$n + m = 1, k=0$	3.2	to be found	?
$n + m = 2, k=0$	3.7	to be found	?
...

Table 13. Baryon states Ω_c . The energies E_C were calculated according to the formula $E_{n,m,k} = 0.5(n + m + 2) + 1.7(k + 1)$. E_M is the measured energy. The error means the absolute value of $(E_C - E_M)/E_C$. We are able, of course, to predict the energies of many other particles.

State(n)	$E_u = E_d$ (GeV)	E_s (GeV)	E_c (GeV)	E_b (GeV)
0	0.31	0.5	1.7	5
1	0.93	1.5	5.1	15
2	1.55	2.5	8.5	25
3	2.17	3.5	11.9	35
...

Table 14. The energy states of quarks u, d, c, s and b.

State	E_n (MeV)	Particles
π_0	135-140	$\pi\pm(140)$, $\pi0(135)$
π_1	405-420	?
π_2	675-700	$\epsilon(\sim 700)$
π_3	945-980	$\eta'(958)$, $f_0(974)$, $a_0(983)$
π_4	1215-1260	$h_1(1170)$, $b_1(1232)$, $a_1(1260)$, $f_2(1275)$, $f_1(1282)$, $\eta(1295)$, $\pi(1300)$
π_5	1485-1540	$\rho(1465)$, $f_1(1512)$, $f_2'(1525)$
π_6	1755-1820	$\pi(1770)$, $\phi_3(1854)$
π_7	2025-2100	$f_2(2011)$, $f_4(2049)$
π_8	2295-2380	$f_2(2297)$, $f_2(2339)$
π_9	2565-2660	to be found
π_{10}	2835-2940	to be found
...

Table 15. The energy states of mesons of the pion family, that is, pion oscillations. E_n was calculated by the formula $\hbar\nu(n + 0.5)$ taking for $\hbar\nu$ the values 270MeV and 280MeV. The error between experimental and calculated values is in general below 3%, for every particle.

State	E_n (MeV)	Particles
π_{0+1}	540-560	$\eta(548)$
π_{0+2}	810-840	$\rho(768), \omega(782)$
π_{0+3}	1080-1120	$\phi(1019)$
π_{0+4}	1350-1400	$a_2(1318), \omega(1394), f_0(1400), f_1(1426), \eta(1420)$
π_{0+5}	1620-1680	$f_0(1587), \omega(1594), \omega_3(1668), \pi_2(1670), \phi(1680), \rho_3(1690), \rho(1700), f_0(1709)$
π_{0+6}	1890-1960	$\phi_3(1854)$
π_{0+7}	2160-2240	to be found
...

Table 16. The energy states of mesons of the pion family which are the result of overtones of the π_0 with all states π_n . The error between experimental and calculated values is in general below 5%, for every particle.

State(K_n)	E_n (MeV)	Particles
K_0	498	$K\pm(494)$, $K0(498)$
K_1	1494	$f'_2(1525)$, $f_1(1512)$, $\rho(1465)$
K_2	2490	to be found
...

Table 17. The energy states of kaons. E_n was calculated by the formula $\hbar\nu(n + 0.5)$ taking for $\hbar\nu$ the value of 996MeV. The error between experimental and calculated values is in general below 2%, for every particle.

State	E_n (MeV)	Particles
$K_0 + \pi_0$	633-638	?
$K_0 + \pi_1$	903-918	$K^*(\pm)(892)$, $K^*(0)(896)$
$K_0 + \pi_{0+1}$	1038-1058	$f_0(974)$, $a_0(983)$, $\phi(1019)$
$K_0 + \pi_2$	1173-1198	$b_1(1232)$, $h_1(1170)$?
$K_0 + \pi_{0+2}$	1308-1338	$f_2(1270)$, $f_1(1282)$, $a_2(1318)$, $K_1(1270)$, $a_1(1260)$?, $\eta(1295)$?, $\pi(1300)$?
$K_0 + \pi_3$	1443-1478	$f_0(1400)$, $f_1(1426)$, $\eta(1440)$, $K_1(1402)$, $K^*(1412)$, $K^*_{0+}(1429)$, $K^*(\pm)_{2+}(1425)$, $K^*(0)_{2+}(1432)$
$K_0 + \pi_{0+3}$	1578-1618	$\omega(1594)$?
$K_0 + \pi_4$	1713-1758	$\pi_2(1670)$, $\phi(1680)$, $\rho_3(1691)$, $\rho(1700)$, $f_0(1709)$, $K^*(1714)$, $K_2(1768)$, $K_{3+}(1770)$
$K_0 + \pi_{0+4}$	1848-1898	$\phi_3(1854)$
$K_0 + \pi_5$	1983-2038	$f_4(2049)$, $K^*_{4+}(2045)$, $f_2(2011)$?
$K_0 + \pi_{0+5}$	2118-2178	to be found
$K_0 + \pi_6$	2253-2318	$f_2(2297)$?, $f_2(2339)$?
$K_0 + \pi_{0+6}$	2388-2458	to be found
...

Table 18. The energies of mesons which are the result of the overtones of K_0 with pions. The interrogation mark means that the decay of the particle into kaons has not yet been found experimentally. The error between experimental and calculated values is below 3%, in general.

State	E_n (MeV)	Particles
D_0	1864	$D\pm(1869)$, $D0(1864)$
D_1	5595	to be found
D_2	9325	to be found
...

Table 19. The energy states of D mesons. E_n was calculated according to the formula $E_n = \hbar\nu(n + 0.5)$ with $\hbar\nu = 3730$ MeV.

State	E_n (MeV)	Particles
$D_0 + \pi_0$	2005	$D*\pm(2010), D*0(2007)$
$D_0 + \pi_1$	2284	to be found
$D_0 + \pi_{0+1}$	2424	$D_10(2424), D_2*(2459)$
$D_0 + \pi_2$	2564	to be found
...

Table 20. The energy states of D mesons which are the result of overtones of D_0 with π_n . The error between experimental and calculated values is in general below 1.5%, for every particle.

State	E_n (MeV)	Particles
$(D_S)_0$	1969	$D_S \pm (1969)$
$(D_S)_1$	5907	to be found
$(D_S)_2$	9845	to be found
...

Table 21. The energy states of D_S mesons. E_n was calculated according to the formula $E_n = \hbar\nu(n + 0.5)$ with $\hbar\nu = 3938\text{MeV}$.

State	E_n (MeV)	Particles
$(D_S)_0 + \pi_0$	2109	$D_S^* \pm (2110)$
$(D_S)_0 + \pi_1$	2389	to be found
$(D_S)_0 + \pi_{0+1}$	2529	$D_{S1} \pm (2537)$
$(D_S)_0 + \pi_2$	2669	to be found
$(D_S)_0 + \pi_{0+2}$	2809	to be found
...

Table 22. The energy states of D_S mesons which are the result of overtones of $(D_S)_0$ with π_n . The error between experimental and calculated values is below 0.5%, for every particle.

State	E_n (MeV)	Particles
B_0	5279	$B0(5279)$, $B\pm(5279)$
B_1	15837	to be found
B_2	26395	to be found
...

Table 23. The energy states of B mesons. E_n was calculated according to the formula $E_n = \hbar\nu(n + 0.5)$ with $\hbar\nu = 10558\text{MeV}$.

State	E_n (MeV)	Particles
$B_0 + \pi_0$	5414-5419	to be found
$B_0 + \pi_1$	5684-5699	to be found
...

Table 24. The energy states of B mesons which are the result of overtones of B_0 with π_n .

State	E_n (MeV)	Particles
$c\bar{c}_0$	2978	$\eta_c(2978)$
$c\bar{c}_1$	8967	to be found
$c\bar{c}_2$	14890	to be found
...

Table 25. The energy states of $c\bar{c}$ mesons. E_n was calculated according to the formula $E_n = \hbar\nu(n + 0.5)$ with $\hbar\nu = 5956$ MeV.

State	E_n (MeV)	Particles
$c\bar{c}_0 + \pi_0$	3113-3118	$J/\Psi(3097)$
$c\bar{c}_0 + \pi_1$	3383-3398	$\chi_{c0}(3415)$
$c\bar{c}_0 + \pi_{0+1}$	3518-3538	$\chi_{c1}(3510), \chi_{c2}(3556)$
$c\bar{c}_0 + \pi_2$	3653-3668	$\Psi(3686)$
$c\bar{c}_0 + \pi_{0+2}$	3788-3818	$\Psi(3770)$
$c\bar{c}_0 + \pi_3$	3923-3958	?
$c\bar{c}_0 + \pi_{0+3}$	4058-4098	$\Psi(4040)$
$c\bar{c}_0 + \pi_4$	4193-4238	$\Psi(4159)$
$c\bar{c}_0 + \pi_{0+4}$	4328-4378	$\Psi(4415)$
$c\bar{c}_0 + \pi_5$	4463-4518	to be found
$c\bar{c}_0 + \pi_{0+5}$	4598-4658	to be found
...

Table 26. The energy states of $c\bar{c}$ mesons which are the result of overtones of $c\bar{c}_0$ with π_n . The error between experimental and calculated values is below 1%, for every particle.

State	E_n (MeV)	Particles
bb_0	9460	$\Upsilon(9460)$
bb_1	28380	to be found
bb_2	47300	to be found
...

Table 27. The energy states of $b\bar{b}$ mesons. E_n was calculated according to the formula $E_n = \hbar\nu(n + 0.5)$ with $\hbar\nu = 18920$ MeV.

State	E_n (MeV)	Particles
$bb_0 + \pi_0$	9595-9600	?
$bb_0 + \pi_1$	9865-9880	$\chi_{b0}(9860)$, $\chi_{b1}(9892)$,
$bb_0 + \pi_{0+1}$	10000-10020	$\Upsilon(10023)$
$bb_0 + \pi_2$	10135-10160	?
$bb_0 + \pi_{0+2}$	10270-10300	$\chi_{b0}(10235)$, $\chi_{b1}(1025)$
$bb_0 + \pi_3$	10405-10440	?
$bb_0 + \pi_{0+3}$	10540-10580	$\Upsilon(10580)$
$bb_0 + \pi_4$	10675-10710	?
$bb_0 + \pi_{0+4}$	10810-10860	$\Upsilon(10860)$
$bb_0 + \pi_5$	10945-11000	$\Upsilon(11020)$
$bb_0 + \pi_{0+5}$	11080-11140	to be found
$bb_0 + \pi_6$	11215-11280	to be found
...

Table 28. The energy states of $b\bar{b}$ mesons which are the result of overtones of $b\bar{b}_0$ with π_n . The error between experimental and calculated values is below 1%, for every particle.

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